Smolt Production, Adult Harvest, and Spawning Escapement of Coho Salmon from the Nakwasina River in Southeast Alaska, 2001-2002

by

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Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Department of Fish and Game	ADF&G
Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	$(F, t, \chi^2, etc.)$
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	E
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

FISHERY DATA REPORT NO. 05–04

SMOLT PRODUCTION, ADULT HARVEST, AND SPAWNING ESCAPEMENT OF COHO SALMON FROM THE NAKWASINA RIVER IN SOUTHEAST ALASKA, 2001-2002

by

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ABSTRACT

In 1998, a coded wire tag (CWT) project was begun for coho salmon in the Nakwasina River near Sitka, Alaska, to supplement a continuing regionwide effort to assess the status of key coho salmon *Oncorhynchus kisutch* stocks in Southeast Alaska. Smolt abundance, adult harvest, and escapement were estimated in 2002, the fourth season of a continuing project. During spring 2001, 10,381 coho salmon smolt ≥70 mm fork length (FL) were captured in minnow traps, marked with an adipose fin clip, given a coded wire tag, and released. Smolt abundance in 2001 was an estimated 43,630 (SE = 2,660). During fall 2002, 48 (of 350,394 sampled) adult coho salmon bearing coded-wire tags with a Nakwasina River code were recovered in random sampling of marine fisheries, and 23.7% of 869 adults examined inriver carried CWTs, as evidenced by adipose fin clips. An estimated 731 (SE = 109) coho salmon of Nakwasina River origin were harvested in Southeast Alaska marine fisheries in 2002. The sport fishery harvested an estimated 133 fish, or 18.2% of the total harvest of Nakwasina River coho salmon, while the commercial troll fishery contributed the remaining 81.8%.

An open-population mark-recapture experiment was also conducted to estimate the abundance of coho salmon in the Nakwasina River during fall 2002. An estimated 3,141 (SE=661) adults escaped into the Nakwasina River. This represents a factor of 4.4 times greater than the peak visual count of 713 adult coho salmon observed during foot surveys of the main river in 2002. The total run (i.e., escapement plus harvest) for all coho salmon bound for the Nakwasina River was 3,872, the marine survival rate was 8.9%, and the marine fishery exploitation was 18.9%.

Key words: coho salmon, *Oncorhynchus kisutch*, Nakwasina River, harvest, troll fishery, sport fishery, migratory timing, return, exploitation rate, marine survival, coded wire tag, mark-recapture experiment, spawning escapement, smolt abundance.

INTRODUCTION

Coho salmon *Oncorhynchus kisutch* produced by the Nakwasina River and thousands of other coastal river systems in Southeast Alaska collectively support the region's mixed stock commercial troll and net fisheries and freshwater and marine sport fisheries. Fishing pressure on coho salmon in Southeast Alaska, particularly along the outer coast of Baranof Island near Sitka, has increased as a direct result of growth in the region's sport fisheries. Fishing pressure on coho has also increased because of increased hatchery productions of coho salmon and reductions in the commercial troll fishery for chinook salmon *Oncorhynchus tshawytscha* (Schmidt 1996). The Alaska Department of Fish and Game (ADF&G) has conducted comprehensive coded wire tag (CWT) assessment projects on a long-term basis to evaluate the effects of Southeast Alaska fisheries on specific coho stocks native to streams in northern and inside areas of Southeast Alaska (Yanusz et al. 1999) but stock-specific information is more limited in outside, central, and southern areas. To bridge geographic areas, projects have been implemented more recently for specific stocks, including the Unuk River in southern Southeast (Jones et al. 1999) and Slippery Creek in central Southeast (Beers 1999). Along the outer coast, the first comprehensive CWT program began at Ford Arm in 1982 and has continued through 2002 (Shaul and Crabtree 1998; Leon Shaul, Personal Communication, Alaska Department of Fish and Game, Commercial Fisheries Division, Douglas). The Division of Sport Fish also conducted a CWT project to assess fishery impacts to Salmon Lake coho salmon from 1983 to 1990 and again in 1994-1995 (Schmidt 1996).

Between 1998 and 2001, Sport Fish Division conducted a CWT project for coho salmon in the Nakwasina River (Figure 1) to supplement the regionwide effort to assess the status of key coho salmon stocks in central Southeast Alaska (Brookover et al. 2001; Tydingco et al. 2003). Estimated smolt abundance in 1998 from the Nakwasina River was 102,794 (SE=15,255), 47,571 (SE = 6,402) in 1999, and 46,575 (SE = 2,722) in 2000. Estimated harvests of returning adults in 1999 - 2001 were 1,983 (SE=605), 1,219 (SE = 231) and 1,439 (SE = 155) respectively.

The objectives of our study were to: (1) estimate the number of coho salmon smolt leaving the Nakwasina River in 2001; (2) estimate the marine harvest of coho salmon from Nakwasina River in 2002 via recovery of CWTs applied in 2001; and (3) estimate spawning escapement in 2002. Sampling and tagging of smolt in the Nakwasina River in 2001 and regionwide sampling of adults harvested in 2002 allowed us to estimate smolt abundance in 2001 and harvest in 2002, while sampling and tagging in the Nakwasina River during 2002 allowed us to estimate spawning abundance.

STUDY AREA

The Nakwasina River (ADF&G Anadromous Stream Catalog No. 113-43-01) is located on the outer coast of Baranof Island in Southeast Alaska (Figure 1). It is about 13 km long, 6 to 30 m wide, and up to 3 m deep, and empties into Nakwasina Sound (57° 15'16.8"w/135° 20'41.5"N) about 23 kilometers north of Sitka. The Nakwasina River drains approximately 8,600 square hectares and is one of the larger river systems on Baranof Island.

The Nakwasina River is known locally for its freshwater sport fisheries for Dolly Varden (*Salvelinus malma)* and coho salmon. Because the Nakwasina River is easily accessed by boat and it supports one of the largest populations of coho salmon in Sitka Sound, it is one of the few rivers near Sitka that attracts freshwater sport fishing effort for coho salmon. From 1984 to 2000, estimated annual harvests of coho salmon in Nakwasina Sound, including the Nakwasina River, ranged from 0 to 182 fish (Mills 1985-1994; Howe et al. 1995-1996, 2001a-d; Walker et al. 2003). Estimated angler effort expended in Nakwasina Sound and River (for all fish species) ranged from 31 to 891 angler days.

In the 1960s, the majority of riparian area in the anadromous portion of the Nakwasina River valley was clear-cut to the stream bank (Greg Killinger, Personal Communication, Sitka Ranger District, U.S. Forest Service, Sitka). Nakwasina River coho salmon are of special concern because of the potential risk of excessive exploitation in combination with the potential negative impacts to the stock from habitat damage due to logging.

Since 1980, visual surveys have been conducted by foot on the Nakwasina River to provide an indication of trends in the annual abundance of coho escapement. Annual peak counts in the Nakwasina River represent the largest of five systems surveyed annually in the Sitka area. Surveys conducted from 1980 to 2002 have documented 47 (1987) to 753 (2001) adult coho salmon spawners observed in the Nakwasina River (Table 1).

METHODS

There were three major components of this study. A 2-event mark-recapture experiment for a closed population was used to estimate the abundance of coho salmon smolt ≥70 mm FL in the Nakwasina River during spring 2001. For this component, coho salmon smolt were sampled and tagged with coded-wire tags during spring 2001 (event 1) and recaptured as returning adults in the Nakwasina River during fall 2002 to estimate the fraction carrying CWTs (event 2). The second component was sampling the marine harvest. Marine harvests were sampled during the summer and fall of 2002 to estimate the tagged fraction and origin of coho captured through commercial fisheries port sampling and recreational fisheries creel survey programs (Oliver 2002; Hubartt et al. 2001). The final component of this study was an open-population mark-recapture experiment conducted fall of 2002 in the Nakwasina River to estimate the spawning escapement of adult coho. Instream mark and recapture events were integrated with coded-wire tag recovery efforts. In addition to the three major parts of this study, we also conducted biweekly foot surveys to compare with our escapement estimate.

SMOLT TAGGING AND SAMPLING

From April 20 to May 17, 2001, between 50 and 100 G-40 minnow traps were baited with salmon roe and fished daily in the Nakwasina River. Traps were fished 24 hours per day approximately 6 days per week and checked at least once each day. Traps were set along mainstem banks and in backwater areas of the lower river between the estuary and approximately 6 km upstream.
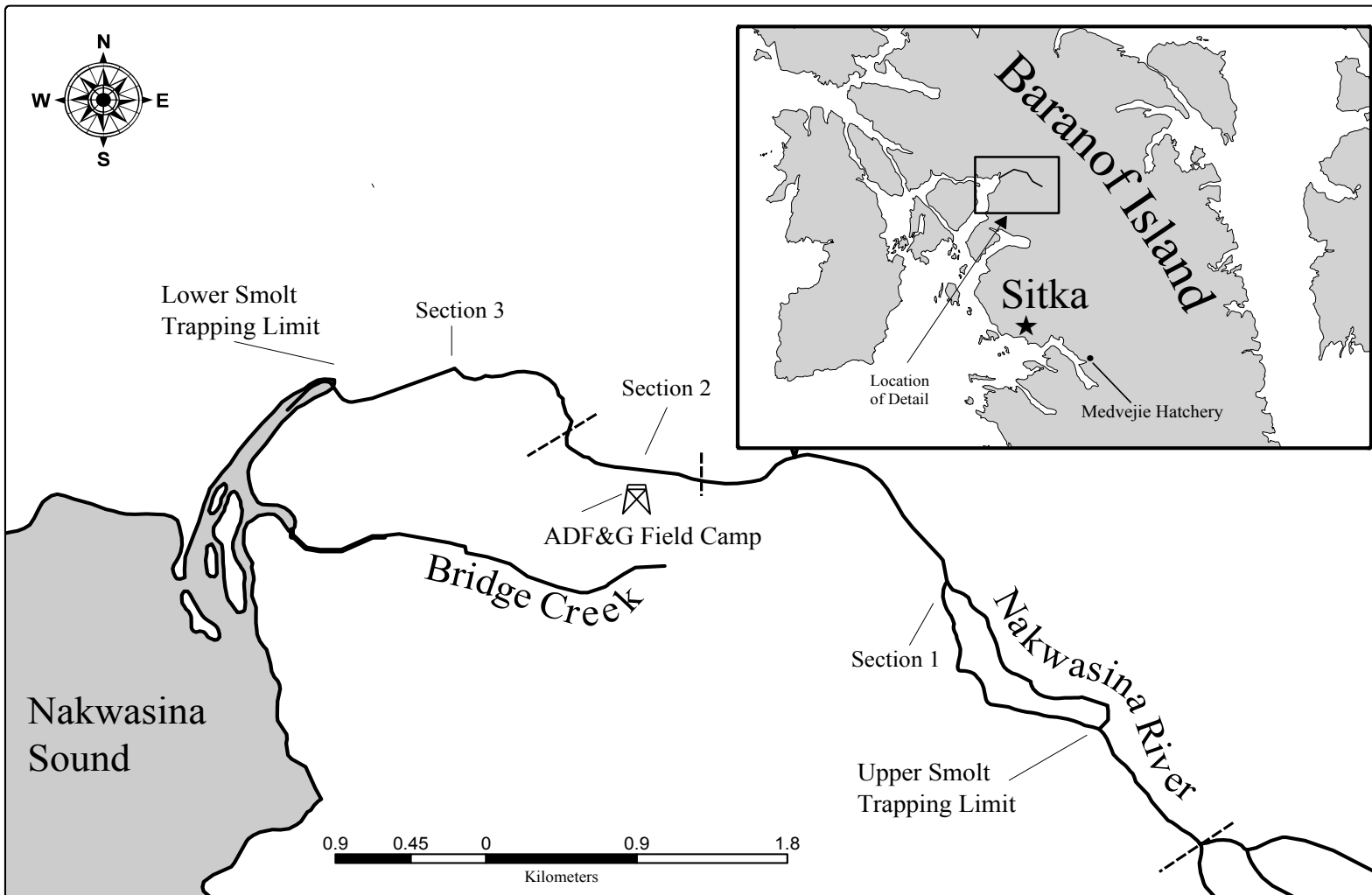
Figure 1.–Map showing Nakwasina River area, including major tributaries and location of ADF&G research sites and stream sections.

Table 1.–Peak coho escapement counts for rivers in the Sitka Area, by date and stream between 1980-2002.

	Sinitsin Creek			St. John Baptist Bay Creek			Starrigavan River			Eagle River			Nakwasina River		
Year	Survey Type	Peak Survey Date	No. of Coho	Survey Type	Peak Survey Date	No. of Coho	Survey Type	Peak Survey Date	No. of Coho	Survey Type	Peak Survey Date	No. of Coho	Survey Type	Peak Survey Date	No. of Coho
1980	Foot	30-Sep	39	Foot	9-Oct	26	Foot						Foot	29-Oct	70
1981	Foot	6-Oct	85	Foot	14-Oct	51	Foot	20-Oct	170	Foot	22-Sep	27	Foot	7-Oct	780
1982	Foot	20-Oct	46	Foot			Foot	21-Oct	317						
1983	Foot	27-Sep	31	Foot	13-Oct	12	Foot	6-Oct	45				Foot	14-Oct	217
1984	Foot	10-Oct	160	Foot	10-Oct	154	Foot	10-Oct	385				Foot	17-Oct	715
1985	Foot	15-Oct	144	Foot	8-Oct	109	Foot	11-Oct	193				Foot	7-Oct	408
1986	Foot	30-Sep	4	Foot	10-Oct	9	Foot	10-Oct	57	Foot	26-Sep	245	Foot	28-Oct	275
1987	Foot	23-Sep	32	Foot	23-Sep	9	Foot	9-Oct	36	Foot	24-Sep	167	Foot	30-Oct	47
1988	Foot	3-Oct	56	Foot	3-Oct	71	Foot	12-Oct	45	Foot	2-Sep	10	Foot	27-Oct	104
1989	Foot	5-Oct	76	Foot	5-Oct	89	Foot	13-Oct	101	Foot	2-Oct	130	Foot	19-Oct	129
1990	Foot	1-Oct	80	Foot	1-Oct	35	Foot	17-Oct	39	Snorkel	2-Oct	214	Foot	31-Oct	195
1991	Foot	1-Oct	186	Foot	10-Oct	107	Foot	2-Oct	142	Snorkel	17-Oct	454	Foot	25-Oct	621
1992	Foot	23-Sep	265	Foot	14-Oct	110	Foot	12-Oct	241	Snorkel	6-Oct	629	Foot	30-Oct	654
1993	Foot	7-Oct	213	Foot	6-Oct	90	Foot	13-Oct	256	Snorkel	13-Oct	513			
1994	Foot	30-Sep	313	Foot	30-Sep	227	Foot	11-Oct	304	Snorkel	1-Oct	717	Foot	14-Oct	404
1995	Foot	26-Sep	152	Foot	5-Oct	99	Foot	6-Oct	272	Snorkel	5-Oct	336	Foot	29-Sep	626
1996	Foot	2-Oct	150	Snorkel	2-Oct	201	Foot	17-Oct	59	Snorkel	30-Sep	488	Foot	30-Oct	553
1997	Foot	29-Sep	90	Snorkel	30-Sep	68	Foot	27-Oct	55	Snorkel	30-Sep	296	Foot	14-Nov	239
1998	Foot	1-Oct	109	Snorkel	9-Oct	57	Foot	8-Oct	123	Snorkel	9-Oct	300	Foot	2-Nov	653
1999	Snorkel	11-Oct	48	Snorkel	29-Oct	25	Snorkel	8-Oct	166				Snorkel	12-Nov	291
2000	Foot	26-Sep	48	Snorkel	26-Oct	32	Snorkel	8-Oct	144	snorkel	29-Sep	108	Foot	8-Nov	419
2001	Foot	5-Oct	62	Snorkel	4-Oct	80	Snorkel	8-Oct	430	snorkel	4-Oct	417	Foot	14-Nov	753
2002	Foot	10-Oct	169	Snorkel	2-Oct	100	Foot	10-Oct	227	snorkel	10-Oct	659	Foot	5-Nov	713
Mean (1980-2002)			111			80			173			329			422
5-yr Mean (1998-2002)			87			59			218			371			566

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Traps were distributed and redistributed opportunistically to maximize catch by targeting areas of likely rearing habitat, unfished areas, and areas known to produce relatively high catch rates. Coho salmon smolt ≥70 mm were removed from minnow traps and transported to holding pens at the campsite each day. Other species (primarily Dolly Varden) and coho fry < 70 mm were counted and released on site.

Every 2-3 days, all live coho salmon smolt ≥70 mm FL were tranquilized with a solution of tricane methane-sulfonate (MS222) and injected with a CWT with one of the following codes: 04-04-66; 04-03-67; or 04-03-68. Fish were then marked externally by excising the adipose fin. Tagging and marking followed the methods of Koerner (1977). All tagged fish were held overnight in a net pen to test for mortality, tag retention, and adipose fin clip status and released. To test for tag retention, 100 fish were randomly selected and passed through a Northwest Marine Portable Sampling Detector™. If tag retention was 98% or greater, all fish were counted, mortalities recorded, and released. If tag retention was 97% or less, all fish were retagged. The number of fish tagged, number of tagging-related mortalities, and number of fish that had shed their tags were recorded on *ADF&G Tagging Summary and Release Information Forms* which were submitted to ADF&G Commercial Fisheries Division (CFD) Tag Lab in Juneau when fieldwork ended.

In 2001, three separate tag codes were used to identify three components of the smolting run. Fish from the Nakwasina that were ≥70 mm but less than 85 mm were tagged with code 04-04-66 while fish ≥85 mm were tagged with code 04-03-67. These two tag codes were used to identify differential survival based on size at smolting. A third tag code (04-03-68) was used for all fish ≥70 mm that were captured in an unnamed tributary to the Nakwasina (Figure 1) that is connected only intermittently. This tributary, referred to as "Bridge Creek," empties into salt water approximately ½ km from the outlet of the Nakwasina River, except at high tides when the two appear to be connected by a small freshwater passage. This third tag code was used to determine if fish originating from this tributary spawn in the mainstem of the Nakwasina. One in every 15 tagged smolt was measured to the nearest 1 mm FL, weighed to the nearest 0.1 g, and sampled for scales. Twelve to 15 scales were removed from the preferred area (Scarnecchia 1979) on the left side of the coho salmon smolt. Scales were sandwiched between two 1x3-in microscope slides and numbered consecutively for each fish. Slides were taped together and the number and length of each fish was written on the frosted portion of the bottom slide according to scale position on the slide.

INSTREAM MARK-RECAPTURE SAMPLING, CODED WIRE TAG RECOVERY, AND MARINE HARVEST SAMPLING

An instream sampling program was designed to periodically deploy external Floy™ tags and recover tagged fish as required for the open-population mark-recapture estimate of adults instream in conjunction with CWT recovery efforts necessary for the closed population estimate of smolt in 2001. Requirements of the open-population experiment demanded the most intensive sampling efforts; sampling methods were therefore designed for the open population experiment, and sampling for CWT recovery became incidental.

From September 5 through December 3, 2002, sampling occurred for 2- or 3-day periods once each week. Adult coho salmon were captured using a 3.6 x 22.5-m, 3.75-cm mesh beach seine and a 3.0 x 35-m, 7.5-cm mesh gillnet. Hook and line gear was also used to supplement net captures.

We divided the stream into three sections (Figure 1). Section 1 extended from river kilometer (rkm) 7.75 downstream to rkm 4.1. The portion of the river upstream of rkm 7.75 was not included because few fish have been observed in this area and the presence of excessive amounts of woody debris and undercut banks were not conducive to capturing fish. Section 2 extended from rkm 4.1 downstream to rkm 3.7 and section 3 extended from rkm 3.7 to rkm 3.4. Sampling was concentrated in sections 2 and 3 most heavily because two large pools contained a majority of adult coho salmon visible in the river at any one time and enabled use of the more effective beach seine. Relatively little sampling occurred below

rkm 3.4 because we wished to avoid potential mortality associated with capturing coho salmon that had recently entered fresh water (Vincent-Lang et al. 1993).

All coho captured were examined for presence or absence of their adipose fin. Between September 5 and December 3, all coho missing adipose fins were sacrificed, their heads removed, and sent to the CFD tag and age lab for dissection and decoding. All captured coho salmon were also examined for an anchor tag and opercle punch combination. All coho salmon absent this combination were measured to the nearest millimeter fork length, tagged with uniquely numbered Floy™ T-Bar anchor tag, given a secondary mark to permit estimation of tag loss, sampled to determine sex and condition, and sampled to collect scales for aging. Tags were inserted just posterior of and 1 cm below the dorsal fin on the left side of the fish. Secondary marks included various combinations of opercle punches that consisted of 0.6 cm diameter holes. The condition of each fish was determined from external characteristics using the following convention:

Bright: Ocean bright or nearly ocean bright;

Blush: Some color (primarily blush red);

Dark: Dark color (primarily red);

LPS (live post-spawner): Spawned out but not yet dead;

Carcass: Dead spawned fish; and,

Mortality: Dead unspawned fish.

For fish captured with an anchor tag, the location, gear used, tag number, and condition of the fish were recorded and the fish was released. If an opercle punch but no anchor tag was present, the fish was recorded as a valid tag recovery (indicating the tag was shed), retagged, and examined for condition. All carcasses that could be retrieved were also inspected for marks, recorded, and removed from the experiment by slashing the left side of the fish. These fish were not counted in subsequent observations.

Sex was determined from external characteristics. Scale samples, consisting of 4 scales from the preferred area near the lateral line on an imaginary line from the insertion of the posterior dorsal fin to the anterior origin of the anal fin (Scarneccia 1979), were collected and affixed to a gum card in the field. Post-season, scale images were impressed on acetate and ages were determined by examining the impressions under a microscope. Criteria used to assign ages were similar to those of Moser (1968).

Harvest in 2002 of coho salmon originating from the Nakwasina River was estimated from fish sampled in commercial and recreational fisheries. Fisheries personnel with the ADF&G CFD port-sampling program examined commercially caught fish at processing locations and recovered coho with missing adipose fins (Alaska Department of Fish and Game Coded Wire Tag Sampling Program 2002). Similarly, the Division of Sport Fish employed a creel survey program to examine fish caught in the sport fishery (Hubartt et al. 2001). When possible, heads of fish without an adipose fin were removed and sent to the ADF&G Coded Wire Tag and Otolith Processing Laboratory for tag detection and decoding. Because multiple fisheries exploited coho salmon over several months in 2002, harvest was estimated over several strata, each a combination of time, area, and type of fishery. Statistics from the commercial troll fishery were stratified by fishing period and by fishing quadrant. Statistics from the recreational fishery were stratified bi-weekly.

FOOT SURVEY COUNTS

Adult coho salmon in the Nakwasina River were counted visually once every two weeks from October 4 to December 3, 2002. Visual counts were conducted by two or three experienced observers wearing polarized lenses during or one day after instream sampling efforts. Only fish positively identified as coho salmon were counted. In braided areas, one observer would walk one braid and the other observer, the adjacent braid. Counts were conducted between the uppermost portion of the survey area (rkm 7.75) and a pool near the high tide mark at rkm 0.25. This survey area included the portion of river below the lower most point of the mark-recapture study area (rkm 3.4) to provide consistency with past counts. Uncontrolled

variables included observer abilities, weather conditions, and water clarity.

Bridge Creek was examined opportunistically approximately every other week during the course of sampling in an attempt to determine if coho used it for spawning as well as rearing.

ESTIMATE OF SMOLT ABUNDANCE AND SIZE

The mark-recapture experiment was designed so that Chapman's modification to the Petersen estimator (Seber 1982) could be used to estimate smolt abundance.

Several conditions must be met for this estimator to be unbiased for this experiment:

1) there is no recruitment or immigration to the population – only fish that were present in the population during the smolt marking are present in the population of fish inspected for marks as adults;

2) there is no tagging induced behavior or mortality – tagged fish behave the same as untagged fish after the marking event;

3) fish do not lose their marks and all marks are recognizable;

4) tag codes and release locations can be correctly determined for all adult fish observed with missing adipose fin; and

5) all fish marked as juveniles are smolt.

In addition, at least one set of conditions on mortality and sampling must be met. Because significant mortality occurs between sampling events, these conditions must be evaluated and satisfied concurrently. At least one of the following sets of conditions must be met:

Set 1. All fish have the same probability of surviving between events whether marked or unmarked and across all tagging groups and all fish have an equal probability of being captured and marked during the first event; or

Set 2. All fish have the same probability of surviving between events whether marked or unmarked and across all tagging groups and either a) complete mixing of marked and unmarked fish occurs prior to the second event or b) all fish have

an equal probability of being captured and inspected for marks during the second event; or

Set 3. All fish have an equal probability of being captured and marked during the first event and either a) complete mixing of marked and unmarked fish occurs prior to the second event or b) all fish have an equal probability of being captured and inspected for marks during the second event.

These conditions were evaluated, where possible, using experimental data and in some cases by indirect knowledge or exercising control over experimental procedures. Equal survival between tagging groups was evaluated using contingency table analysis to test for lack of independence between tagging group and probability of recovery during adult sampling. Contingency table analysis was also used to test for lack of independence between sampling events and occurrence of freshwater age of fish at smolting.

For this experiment on the Nakwasina River from 2001 to 2002, coho smolt survival to adult size was different ($p<0.001$, Table 2) between large (≥ 85 mm) and small smolt tagged in the Nakwasina River and those tagged in Bridge Creek based on tag recovery in adults. Another condition that is not met is that all smolt must have the same probability of being marked regardless of their size. In the Nakwasina River, smaller smolt were less likely to be captured in 2001 than were larger smolt. The experimental design did not provide for this evaluation for smolt tagged in Bridge Creek. Also, there is no test to evaluate equal tagging probability between Bridge Creek and Nakwasina River smolt.

Under these circumstances, no clearly unbiased estimate of abundance of coho salmon can be calculated. The best, albeit biased, estimator for which the potential biases can be described is a weighted variant of Chapman's modification to the Petersen estimator:

$$\hat{N} = \frac{(\hat{A}M_1 + M_2 + 1)(C + 1)}{\hat{A}(R_1 + \hat{\pi}_1 R_3) + (R_2 + \hat{\pi}_2 R_3) + 1} - 1 \qquad (1)$$

where M is the number of Nakwasina River smolts marked by size group (1 = smaller 70-85 mm FL, 2 = larger >85 mm FL) in 2001, C the

Table 2.–Numbers and Chi Square tests for independence for smolt and adult coho from the Nakwasina River and Bridge Creek in 2000-2002, by tag code.

	2001-2002			2000-2001		
	Nakwasina R. ≥70 mm	Nakwasina R. ≥85 mm	Bridge Creek ≥70 mm	Nakwasina R. ≥70 mm	Nakwasina R. ≥85 mm	Bridge Creek ≥70 mm
Tag Code	04-04-66	04-03-67	04-03-68	04-04-16	04-04-17	04-04-18
Smolt tagged	6,979	1,434	1,968	5,446	1,831	3,042
Percentage of total	(67.2%)	(13.8%)	(19.0%)	(52.8%)	(17.7%)	(29.5%)
Adults recovered in escapement	146	39	15	75	35	40
Percentage of total	(73.0%)	(19.5%)	(7.5%)	(50.0%)	(23.3%)	(26.7%)
Adults recovered in fisheries	26	22	5	48	22	29
Percentage of total	(49.1%)	(41.5%)	(9.4%)	(48.5%)	(22.2%)	(29.3%)
All adults combined	172	61	20	123	57	69
Percentage of total	(68.0%)	(24.1%)	(7.9%)	(49.4%)	(22.9%)	(27.7%)

Component 1	Component 2	χ^2	p
Smolt 2001	All Adults 2002	36.64	<0.001
Smolt 2001	Adult Escapement 2002	19.91	<0.001
Nakwasina Small 70-84 mm	Nakwasina Large ≥85 mm	13.5	<0.001
Adult Fisheries 2002	Adult Escapement 2002	12.15	0.0023
Smolt 2000	All Adults 2001	4.64	0.0983
Smolt 2000	Adult Escapement 2001	3.31	0.1907
Adult Fisheries 2001	Adult Escapement 2001	0.21	0.9011

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number of adults in 2002 inspected for marks, R the subset of C with marks representing a size group of smolts (3 = group unknown), A is the ratio of the catchability coefficients for larger (>85 mm FL) to smaller (≥ 85 mm FL) Nakwasina River smolt in 2001, and π_i is the fraction of adults in 2002 that were smaller or larger Nakwasina River smolts in 2001. Smolt tagged in Bridge Creek in 2001 are not used in this estimator, except observed adults are used to estimate π_i parameters. Smolt tagged in Bridge Creek are considered "unmarked."

The estimate A is used to adjust for differences in catchability in 2001 such that $A > 1$, when larger smolt are more catchable and < 1 when larger smolt are less catchable. Because some recaptured fish are not sacrificed to find tags or some marked adults do not contain tags, π_i's are used to assign recaptured fish of unknown pedigree to the appropriate smolt size group. An estimate of π is:

$$\hat{\pi}_i = \frac{T_i}{T_1 + T_2 + T_{BC}} \qquad (2)$$

where T_i is the number of all tags representing a smolt size group ($i=1,2$) recovered or recaptured from adult salmon regardless of how or where recovered or recaptured and T_{BC} are adults tagged as smolt in Bridge Creek. Recovery of all tags in 2002 from both Nakwasina River smolt groups indicates that smolt in the larger-size group survived about 73% better than did smaller smolt ($P < 0.001$, $\chi^2 = 13.5$, df $= 1$, Table 2).

Vincent-Lang (1993) has shown that coho salmon smolts marked as in this project and handled competently suffer no detectable mortality from the experience. Also, there is no reason to believe that capture rates for adults is influenced by the code on a tag imbedded deep within its cartilage. For these reasons, the differences in recovery rates is most likely due to natural differences in survival rates.

Evidence for smolts not having equal probability of being marked regardless of size can be found thru calculations based on estimates of relative freshwater age composition of smolts and adults. Catchability of Nakwasina River smolt in the larger size group was about 3 times greater than catchability of smaller smolt in 2001. If $\hat{p}$ is the estimated fraction of all <u>adults</u> that are of

age 1-freshwater, if $\hat{\phi}_1$ is the estimated fraction of <u>smolts</u> in the smaller-size group that were age 1-freshwater, and if $\hat{\phi}_2$ is the estimated fraction of <u>smolts</u> in the larger-size group that were age 1-freshwater, an estimate of the ratio of catchability coefficients for larger to smaller smolt is:

$$\hat{A} = \frac{T_2(\hat{\phi}_2 - \hat{p})}{T_1(\hat{p} - \hat{\phi}_1)} \qquad (3)$$

(see appendix for derivation of equation 3). From tagging records, $\hat{\phi}_1$ = 256/256 = 1.0 and $\hat{\phi}_2$ = 47/70 = 0.6714. Of the 688 adults sampled for age in the Nakwasina River in 2002 (Table 3), 663 were age 1.1, making $\hat{p}$ = 0.9637. Given that T_1 = 172 and T_2 = 61 in 2002, $\hat{A}$ = 2.89. Simulations (see below) indicate that this estimated rate is statistically different than 1.

Variance and 95% credibility interval for the estimator (equation 1) were estimated using empirical Bayesian methods (Carlin and Louis 2000). Using Markov Chain Monte-Carlo techniques, posterior distributions for $\hat{N}$ and $\hat{A}$ were generated by collecting 100,000 simulated values of $\hat{N}'$ and $\hat{A}'$ which are calculated using equations (1) and (3) from simulated values of equation parameters. Simulated values were modeled from observed data using the following distributions:

observed 26 = H_1 ~binomial(H_1'/6979, 6979);

observed 22 = H_2 ~binomial(H_2'/1434, 1434);

observed 5 = H_{BC} ~binomial(H_{BC}'/1968, 1968);

observed 146 = R_1 ~binomial(R_1'/(6979-H_1'), 6979-H_1');

observed 39 = R_2 ~binomial(R_2'/(1434-H_2'), 1434-H_2');

observed 15 = R_{BC} ~binomial(R_{BC}'/(1968-H_{BC}'), 1968-H_{BC}');

$T_i' = H_i' + R_i'$ for $i = 1,2$, and BC;

observed 6 = R_3 ~binomial(R_3'/206, 206);

observed 256 = 256*$\hat{\phi}_1$ ~binomial($\hat{\phi}_1'$,256);

observed 47 = 70*$\hat{\phi}_2$ ~binomial($\hat{\phi}_2'$,70); and

observed 663 = 688*$\hat{p}$ ~binomial($\hat{p}$,688).

Table 3.–Number of freshwater age-1 and freshwater age-2 coho salmon smolt and adults in the Nakwasina River, 2000 and 2001 versus 2001 and 2002.

	1.1	2.1	Proportion Age-2		1.1	2.1	Proportion Age-2
Adult 2001	701	19	0.03	Adult 2002	663	25	0.04
Smolt 2000	397	13	0.03	Smolt 2001	368	41	0.10
	Chi Square	0.27			Chi Square	18.53	
	P=	0.6043			P=	<0.001	

At the end of the iterations, the following statistics were calculated:

$$\overline{N}' = \frac{\sum_{b=1}^{100000} \hat{N}'_{(b)}}{100000} \quad (4a)$$

$$\text{var}(\hat{N}) = \frac{\sum_{b=1}^{100000} (\hat{N}'_{(b)} - \overline{N}')^2}{100000 - 1} \quad (4b)$$

Similar formulas were used to calculate $\overline{A}'$ and var($\hat{A}$).

Estimates of mean smolt length and weight-at-age and their variances were calculated with standard sample summary statistics (Cochran 1977).

ESTIMATE OF HARVEST

The contribution (r_{ij}) of release group j to a fishery stratum i was estimated as:

$$\hat{r}_{ij} = N_i \left[\frac{m_{ij}}{\lambda_i n_i} \right] \theta_j^{-1}; \qquad \lambda_i = \frac{a_i' t_i'}{a_i t_i} \quad (5)$$

where:

N_i = total harvest in fishery stratum i,

n_i = number of fish inspected in fishery stratum i (the sample),

a_i = number of fish which were missing an adipose fin,

a_i' = number of heads that arrived at the lab,

t_i = number of heads with CWTs detected,

t_i' = number of CWTs that were dissected from heads and decoded,

m_i = number of CWTs with code(s) of interest, and

θ_j = fraction of the cohort tagged with code(s) of interest.

When N_i and θ_j are known without error, an unbiased estimate of the variance of (1) can be calculated as shown by Clark and Bernard (1987). However, N_i is estimated with error in our sport fisheries, and θ_j is estimated with error on the Nakwasina River since wild stocks are tagged. Because of these circumstances, estimates of the variance of $\hat{r}_{ij}$ based on large sample approximations were obtained using the appropriate equations in Table 2 of Bernard and Clark (1996).

The total harvest for a cohort was calculated as the sum of strata estimates:

$$\hat{H} = \sum_i \sum_j \hat{r}_{ij} \quad (6)$$

$$Var\left[\hat{H}\right] = \sum_i \sum_j v\left[\hat{r}_{ij}\right] \quad (7)$$

SPAWNING ESCAPEMENT

The escapement of adult (1-ocean age) coho salmon in the Nakwasina River was estimated from a Jolly-Seber (JS) experiment (Seber 1982) using the model described by Schwartz et al. (1993). Sub-adult (0-ocean age) coho salmon were rarely encountered and were much smaller than adults, and were ignored. Weekly sampling trips spanning the breadth of the river and time of immigration were conducted to mark and recapture adults. Following the work of Sykes and Botsford (1986), we did not include repeated recaptures of carcasses "captured" in a decayed condition.

In general, escapement (E) is the total number of immigrants (B_i) between the first and last sampling occasion, including fish that enter the system and die between any two sampling occasions (i) and fish that enter before the first sampling occasion (B_0) and after the last sampling occasion (B_s): $\hat{E} = \hat{B}_0 + ... + \hat{B}_{s-2} + \hat{B}_{s-1} + B_s$. Because we began sampling while immigration was low and continued it until recruitment was virtually over, we estimated $B_0 + B_1$ from an estimate of abundance just before the second JS sampling event (N_2) and ignored any small immigration B_{s-1} and beyond as suggested by Schwarz et al (1993). The resulting (albeit biased low) estimator is thus

$$\hat{E} = \hat{N}_2\left(\frac{log\,\hat{\phi}_1}{\hat{\phi}_1 - 1}\right) + \hat{B}_2\left(\frac{log\,\hat{\phi}_2}{\hat{\phi}_2 - 1}\right) + ... + \hat{B}_{s-2}\left(\frac{log\,\hat{\phi}_{s-2}}{\hat{\phi}_{s-2} - 1}\right) \quad (8)$$

where $\hat{B}_i$ are JS estimates of the number of fish present at the sample time $i+1$ which immigrated between i and $i+1$, $\hat{\phi}_i$ is the survival rate from i to $i+1$, and the factors $\frac{log(\phi_i)}{\phi_i - 1}$ account for fish that enter and die between samples under the assumption that recruitment is uniformly distributed between samples. The computer program POPAN (Arnason and Schwarz 1995) was used to estimate the JS parameters, and out-of-bounds estimates were constrained to admissible values (Schwarz et al. 1993, Schwarz and Arnason 1996). Variance of escapement was estimated using the delta method and the asymptotic variance and covariances in Schwarz et al. (1993), and expected values of the sampling statistics from POPAN.

Assumptions of the standard (full) JS model (Seber 1982) include:

1. every fish in the population has the same probability of capture in the ith sample;

2. every marked fish has the same probability of surviving from the ith to the $(i+1)^{th}$ sample and being in the population at the time of the $(i+1)^{th}$ sample;

3. every fish caught in the ith sample has the same probability of being returned to the population;

4. marked fish do not lose their marks between sampling events and all marks are reported on recovery; and

5. all samples are instantaneous (sampling time is negligible).

Chi-square goodness of fit tests were used to test for homogeneous capture and survival probabilities by tagged status (Pollock et al. 1990). The first test is equivalent to the Robson (1969) test for short-term mortality. The second test is reported to be better at detecting heterogeneous survival probabilities (Pollock et al. 1990: 24). The sum of the chi-squares from each test is an overall test statistic for violations of the first three assumptions above (equal probability of capture, survival, and return to the population).

The equal probability of capture assumption can also be violated if sampling is size or sex selective. Although differences in the size of adult coho salmon are small, a hypothesis that fish of different sizes were captured with equal probabilities was tested by using Kolmogorov-Smirnov (K-S) 2-sample tests (Appendix A3). Sex selective sampling was investigated using a χ^2 test comparing the number of males and females marked with those recaptured. Assumptions 3, 4, and 5 were thought to be robust in this experiment.

AGE AND SEX COMPOSITION:

The proportion of the spawning population composed of a given age or sex was estimated as:

$$\hat{p}_j = \frac{n_j}{n} \quad (9)$$

$$Var(\hat{p}_j) = \frac{\hat{p}_j(1 - \hat{p}_j)}{n - 1} \quad (10)$$

where:

$p_j =$ the proportion in the population in group j;
$n_j =$ the number in the sample of group j; and
$n =$ sample size.

To reduce bias due to in-season changes in age composition, samples were obtained systematically.

ESTIMATES OF TOTAL RUN, EXPLOITATION, AND MARINE SURVIVAL

Estimates of total run (i.e., harvest and escapement) for coho salmon returning to the Nakwasina River in 2002 and the associated exploitation rate in commercial and sport fisheries are based on the sum of the estimated harvest and escapement:

$$\hat{N}_R = \hat{H} + \hat{E} \qquad (11)$$

The variance of the estimated run was calculated as the sum of the variances for estimated escapement and harvest:

$$Var[\hat{N}_R] = Var[\hat{H}] + Var[\hat{E}] \qquad (12)$$

The estimate of exploitation rate and variance were calculated using (Mood et al, 1974):

$$\hat{U} = \frac{\hat{H}}{\hat{N}_R} \qquad (13)$$

$$Var[\hat{U}] \approx \frac{Var[\hat{H}]\hat{E}^2}{\hat{N}_R^4} + \frac{Var[\hat{E}]\hat{H}^2}{\hat{N}_R^4} \qquad (14)$$

The estimated survival rate of smolt to adults and variance were calculated using (Mood et al, 1974):

$$\hat{S} = \frac{\hat{N}_R}{\hat{N}_s} \qquad (15)$$

$$Var[\hat{S}] \approx \hat{S}^2 \left[\frac{Var[\hat{N}_R]}{\hat{N}_R^2} + \frac{Var[\hat{N}_s]}{\hat{N}_s^2} \right] \qquad (16)$$

RESULTS

SMOLT TAGGING, SAMPLING, AND ABUNDANCE IN 2001

Between April 15 and May 17, 2001, 10,390 coho smolt from the Nakwasina River and its tributary were captured, tagged, and their adipose fins removed. Tag retention was 100% with 9 overnight mortalities. This left 10,381 valid tag releases. Of these smolt, 6,979 (67%) were captured in the mainstem of the Nakwasina and were ≥70 mm but <85 mm. Fourteen percent (14%) were ≥85 mm and 19% were fish ≥70 mm from Bridge Creek.

Smolt captured in the mainstem of the Nakwasina that were age-1 fish (those rearing for one year in fresh water) comprised 93% of sampled smolt and averaged 78.7 mm FL (SE = 0.42) and 5.5 g (SE = 0.09) (Table 4). Age-2 coho smolt from the mainstem Nakwasina averaged 101.8 mm FL (SE = 1.76) and 10.9 g (SE = 0.53). The combined catch averaged 80.5 mm FL (SE=0.54) and 6.0 g (SE=0.13). Average length and weight of captured coho remained approximately the same throughout the tagging effort.

From Bridge Creek, age-1 fish comprised 78% of sampled smolt and averaged 80.5 mm FL (SE = 0.68) and 5.5 g (SE = 0.13) (Table 4). Eighteen age-2 coho smolt were sampled from Bridge Creek and averaged 94.3 mm (SE = 5.28) and 9.6 g (SE = 0.13). The combined lengths and weights of Bridge Creek smolt averaged 83.5 mm (SE = 1.38) and 6.4 g (SE = 0.24).

The proportions of smolt tagged in 2001 with each of three tag codes were significantly different than that observed in the spawning escapement in 2002 (χ^2 = 19.9, P <0.001, Table 2). All three tag groups apparently had different survival based on rates of recovery of tagged adult fish. Tagged adults from Bridge Creek were not used to estimate smolt abundance because their survival was different than fish tagged in the Nakwasina River and we have no data to evaluate if the probability of a smolt being tagged was the same for both rearing areas.

During tagging, larger smolt (≥85mm) were caught and tagged at approximately 3 times the rate of smaller smolt. The point estimate $\hat{A}$ =2.89 is slightly biased and the mean parameter estimate from simulation results $\overline{A'}$ = 3.00 (SE = 1.02) is preferred. The point estimate of abundance (equation. 1) based on smolt groups tagged in the Nakwasina River is 39,461. From the simulation results, we estimate the SE of the abundance estimate is approximately 3,057 and the 95% credibility interval for the abundance estimate is 34,290–46,270. Because tagged fish from Bridge Creek were treated as unmarked fish for this

Table 4.–Estimated length, weight and age of coho salmon smolt from the Nakwasina River and Bridge Creek in 2001.

| | Nakwasina | | | | | | Bridge Creek | | | | | |
| | Age 1 | | Age 2 | | Combined | | Age 1 | | Age 2 | | Combined | |
Statistic	Length[a]	Weight[a]	Length	Weight	Length	Weight	Length	Weight	Length	Weight	Length	Weight
Mean	78.7	5.5	101.8	10.9	80.5	6.0	80.5	5.5	94.3	9.6	83.5	6.4
Standard Error	0.42	0.09	1.76	0.53	0.54	0.13	0.68	0.13	1.73	0.56	1.05	0.24
Sample Size	303	303	23	23	329	329	65	65	18	18	84	84
	% age 1 fish in the Nakwasina = 93%						% age 1 fish in Bridge Creek = 78%					

[a] Length measured to the nearest millimeter and weight to the nearest tenth gram

estimate, it is necessary that Bridge Creek smolt have the same survival as Nakwasina River smolt for this estimate to be unbiased. Because fish tagged in Bridge Creek were found to spawn in the mainstem of the Nakwasina and no fish were found to spawn in Bridge Creek, Bridge Creek was assumed to be a part of the Nakwasina River coho rearing system. From the tag recovery data (Table 2), it appears that survival of Bridge Creek smolt was approximately 40% of that for Nakwasina River smolt.

The estimate of 39,461 is biased low. Unfortunately, attempts to assess the bias are, at best, speculative because no data are available to measure differences in probability of tagging between the two rearing areas. However, if the probabilities of a smolt being tagged were approximately the same for both Nakwasina River and Bridge Creek, the 15-20% of the smolt in the Nakwasina system were in Bridge Creek when tagging was conducted. We can project that the true smolt abundance was 1.2 to 1.3 times our estimated value. If Bridge Creek smolt were tagged at a higher rate than Nakwasina River smolt, the potential bias is not so severe. If Bridge Creek smolt were tagged at a lower rate than Nakwasina River smolt, the potential bias is, of course, greater than we projected.

Unlike tagged 2001 smolt, coho smolt tagged in 2000 and recovered in 2001 in escapement sampling exhibited a recovery rate similar to their tagged rate (Table 2).

INSTREAM MARK-RECAPTURE SAMPLING AND CODED WIRE TAG RECOVERY

The tagged fraction of adult coho salmon sampled in the Nakwasina River during 2002 was 0.237. Of the 869 adult coho salmon examined, 206 had an adipose fin clip (Table 5).

The proportion of freshwater age-1 fish was significantly different (χ^2 = 18.5, P <0.001) between smolt sampled in 2001 and adults sampled inriver during 2002 (Table 3). Both groups, however, were predominately ($\geq$90%) freshwater age-1. fish.

Length distributions of adult coho salmon captured in 2002 in the Nakwasina River were not different between sex or time of capture (K-S Tests, Figure 2). Hook and line gear caught significantly smaller fish (579 mm (SE = 8.95)) than did the seine (mean length 617 mm (SE = 1.98)). A higher proportion of males were captured at tidewater than the other 3 sections (χ^2 = 7.5 P = 0.056, Table 6), but no significant differences in sex composition were observed between the 3 primary sections. No significant difference in sex composition was detected between gear types or between capture and recapture (Table 6).

Most (782) adult coho captured in the Nakwasina River in 2002 were captured with the beach seine or gillnet, while 87 were captured with hook and

Table 5.– Proportion of recovered Nakwasina River adult coho observed with and without adipose fin clips.

Date	No Clip	Clip Observed	Tagged Proportion
5-Sep	5	1	0.17
11-Sep	6	2	0.25
17-Sep	16	1	0.06
23-Sep	8	8	0.50
25-Sep	15	2	0.12
26-Sep	5		0.00
30-Sep	18	5	0.22
4-Oct	1		0.00
10-Oct	2	1	0.33
11-Oct	7	2	0.22
14-Oct	37	10	0.21
15-Oct	14	3	0.18
23-Oct	7	2	0.22
24-Oct	15	6	0.29
25-Oct	41	23	0.36
26-Oct	25	17	0.40
28-Oct	3	1	0.25
29-Oct	60	19	0.24
30-Oct	56	25	0.31
6-Nov	30	6	0.17
7-Nov	55	16	0.23
8-Nov	36	9	0.20
13-Nov	49	12	0.20
14-Nov	45	8	0.15
15-Nov	21	5	0.19
21-Nov	37	11	0.23
22-Nov	9	1	0.10
25-Nov	33	8	0.20
3-Dec	7	2	0.22
Total	663	206	0.24

Table 6.– Differences in sex composition between capture type, gear, and location.

Capture	Females	Males	% Males	$\chi 2$	p-value
Recaptured	44	98	69.0%	2.70	0.1002
Capture	331	536	61.8%		
Gear Type					
Hook and Line	33	47	58.8%	2.50	0.1139
Seine	43	97	69.3%		
Location					
Tide water	31	32	50.8%	7.50	0.0575
Section 1	52	81	60.9%		
Section 2	143	276	65.9%		
Section 3	105	147	58.3%		
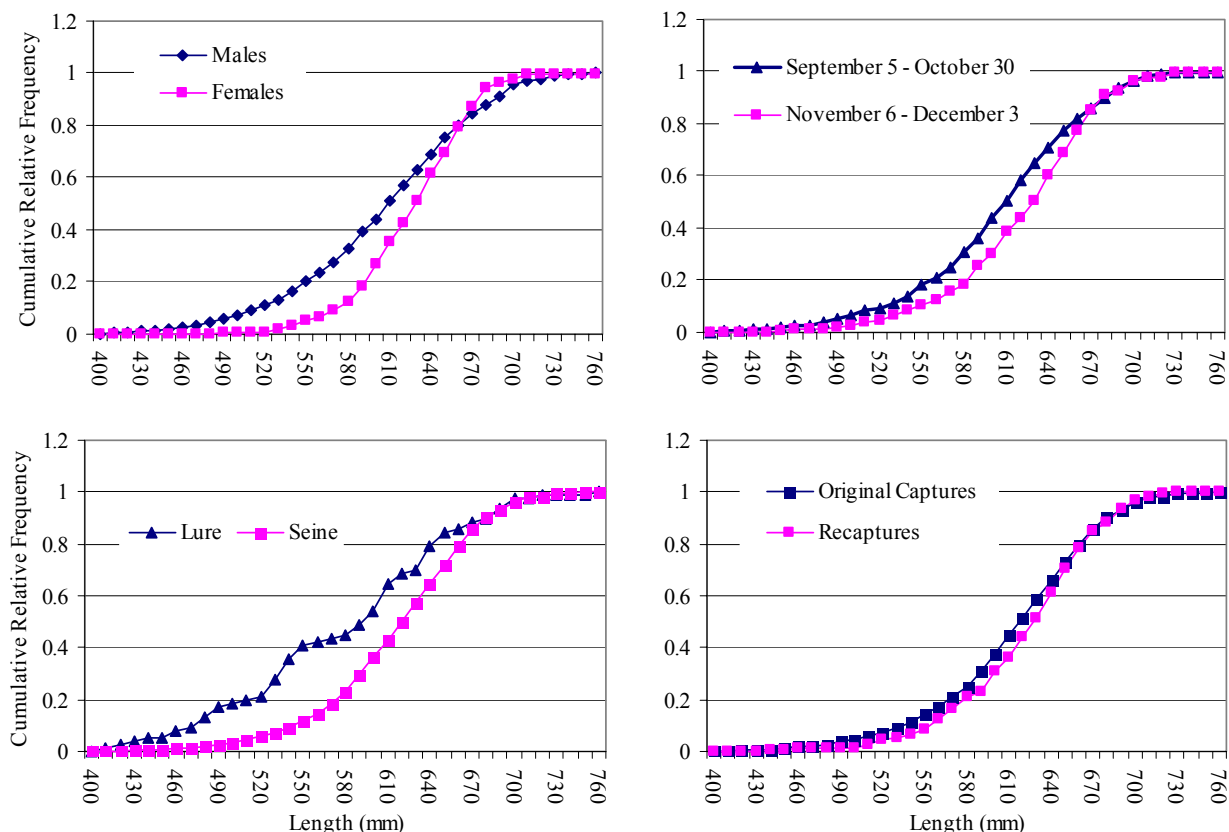
Figure 2.–Cumulative length frequency distributions to test for differences in lengths of captured coho by sex, time, gear, and capture or recapture.

line. Hook and line gear was moderately effective at capturing fish but only when water conditions allowed for sighting fish. The use of a beach seine or gillnet seemed to be the most effective means of capture.

CONTRIBUTION OF SMOLT TAGGED IN 2001 TO HARVEST IN 2002

In 2002, 49 CWTs from the Nakwasina River were recovered from 350,394 coho salmon sampled in commercial and sport fisheries and 5 additional CWTs were recovered incidentally (Appendix A1). Forty-one coho salmon bearing CWTs with a Nakwasina River code were recovered randomly from Southeast Alaska's commercial troll fisheries, 40 of which could be used to estimate commercial harvest. Of these 40, all but three were caught in the Northwest Quadrant (Figure 3) of Southeast Alaska between

July 4 and October 1, 2002. Ten coho salmon bearing CWTs with a Nakwasina River code were recovered in the Sitka sport fishery between July 23 and October 2, 8 of which were random recoveries. No fish were recovered in the commercial gillnet fisheries.

The estimated harvest of Nakwasina River coho salmon in sampled marine fisheries in 2002 was 731 (SE = 5; Table 7). Nakwasina coho contributed less than 1% of the combined sport and commercial troll harvest (1,083,992) for the areas in which Nakwasina River fish were recovered. The total contribution to the sport fishery by Nakwasina coho was estimated at 133 fish. Sport caught Nakwasina coho comprised 18.2% of the harvest of that stock in the sampled marine fisheries, but relative contributions were higher for the sport harvest (0.3%) than the troll harvest (0.1%).Freshwater harvest of coho salmon

Figure 3.–Map of Southeast Alaska showing the boundaries for CWT quadrants.

Table 7.–Estimated harvest of adult Nakwasina River coho salmon (tag codes 04-04-66, 04-03-67, and 04-03-68) in sampled in sport and commercial fisheries in 2002.

			TROLL FISHERY								
Period	Dates	Quadrant	Estimated Harvest	Inspected	a	a'a	t	t't	m	r	SE{r}
3	6/30-8/10	NE	102,015	35,428	1,363	1,351	1,200	1,197	1	12	12
3	6/30-8/10	NW	341,306	113,254	2,224	2,210	1,845	1,844	7	91	33
4	8/11-10/5	NE	82,886	26,757	866	857	739	737	1	13	13
4	8/11-10/5	NW	461,263	125,974	3,234	3,201	2,819	2,817	30	475	89
4	8/11-10/5	SW	50,368	35,540	518	511	407	407	1	6	6
Subtotal troll fishery			1,037,838	336,953	8,205	8,130	7,010	7,002	40	598	12

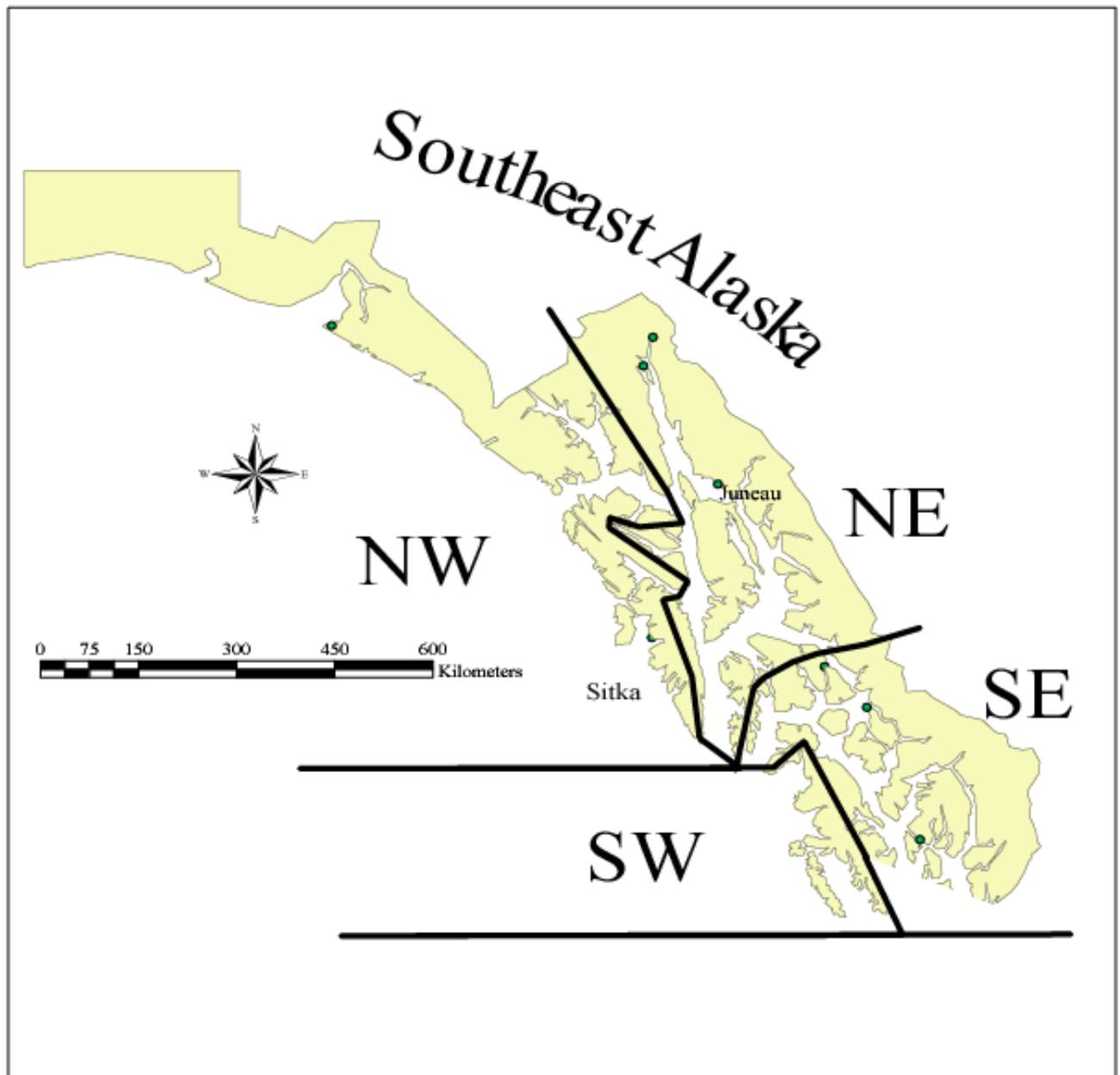|			SPORT FISHERY								
Biweek	Dates	Area	Estimated Harvest	Inspected	a	a'a	t	t't	m	r	SE{r}
11-15	5/27-8/4	SITKA	24,762	6,627	127	126	110	109	3	49	28
16-17	8/5-9/1	SITKA	19,393	6,551	204	201	175	175	4	51	26
18-19	9/2-9/29	SITKA	1,999	263	8	8	8	8	1	33	32
Subtotal sport fishery			46,154	13,441	339	335	293	292	8	133	9
Total All Fisheries			1,083,992	350,394	8,544	8,465	7,303	7,294	48	731	5

in the Nakwasina River will not be available until the Division of Sport Fish publishes the results of its annual mail-out angler survey.

Coho salmon bearing CWTs with a Nakwasina River code recovered in the commercial and sport fisheries averaged 616 mm FL (SE = 3.47).

ESTIMATED SPAWNING ESCAPEMENT, TOTAL RUN, AND MARINE SURVIVAL

Coho salmon were marked and recaptured in all 14 weeks of the study. Altogether, 869 individual adults were captured and examined, of which 835 were marked and released alive and 173 (Table 8) recaptures were made, comprised of 147 individual fish (several fish were recaptured multiple times). Only four recaptured fish had lost their numbered tag as evidenced by the operculum punches. A total of 209 fish were sacrificed for their CWTs or died upon capture, and 23 tagged fish were recaptured more than once during one

Table 8.–Summarized mark-recapture data for Nakwasina River coho salmon 2002. Notation follows that in Seber (1982).

Week	Number Captured	Number Marked caught in *mi*	Losses on Capture	Subsequently Recaptured
1	6		1	1
2	8	1	2	3
3	17		3	3
4	38		10	6
5	24	2	5	5
6	12		3	3
7	64	1	12	18
8	136	4	49	37
9	164	15	46	39
10	152	42	31	32
11	140	53	26	17
12	58	25	12	7
13	41	18	8	2
14	9	12	2	
Totals	869	173	210	173

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sampling period. No recaptured fish died upon recapture or were killed. These measures should have prevented any duplicate samplings. Details of the marking and recovery by location are shown in Appendix A2.

Small sample sizes in several weeks led us to pool data (2 through 4; and 5 through 7) for 10 periods instead of 14 (weeks) for data analysis. In-stream abundance peaked at 1,407 adults in sample-period 3 and declined to 698 fish in sample-period 8 (Table 9). Period-to-period survival rates varied from 1.0 to 0.60 (Table 9).

The estimated spawning escapement of coho salmon in the Nakwasina River was 3,141 fish (SE = 661). Goodness of fit tests (Table 10) suggested the JS model fit the data well. Two estimates of survival and three recruitment estimates were constrained to yield admissible (realistic) values during the estimation procedure (Table 9).

Nineteen percent (19%) of the sample was captured or recovered in section 1, 48% at location 2, and 33% at location 3 or below (Table 11); in total, 20.1% of the fish inspected for Floy™ tags had either a Floy™ tag or a secondary mark. The probability of capturing a tagged fish was significantly higher in section 1 than in section 2 or 3 (Table 11).

Based on an escapement estimate of 3,341, a coho salmon marine harvest of 731 fish, and smolt abundance of 43,630, we estimated the total run in 2002 to be 4,072 (SE = 666) and ocean survival to be 8.9% (SE = 0.46%). Total exploitation was estimated to be 18.9% (SE = 1.45%).

VISUAL COUNTS

Visual counts were conducted on the Nakwasina River on 5 occasions in 2002 (Table 12). The peak count (713) occurred November 5 (Table 12) and represented 22.7% of the estimated total escapement. The area between river kilometer 7.75 (the upper end of the sampling area) and river kilometer 13.0 was inspected for coho in November, but few fish were seen.

DISCUSSION

SMOLT ABUNDANCE AND ADULT HARVEST

To estimate smolt abundance and adult harvest we assumed:

1) all smolts had an equal probability of being marked in 2001; or

2) all adults had an equal probability of being inspected for CWT marks in 2002; or

3) marked fish mixed completely with unmarked fish in the population between years;

4) there was no recruitment, immigration, or emigration to the population between years;

5) there was no tagging induced behavior or mortality;

6) fish did not lose their marks and all marks were recognizable;

7) tag code and release locations were correctly determined for all fish observed with a missing adipose fin;

8) smolt emigrating from the unnamed tributary mix completely and spawn with the mainstem Nakwasina fish; and

9) marked fish at the Nakwasina River were smolt.

We believe that most of these assumptions were satisfied. The first assumption required that all smolt had the same probability of capture regardless of time of smolting, location in the river, or size. Smolt capture and tagging occurred throughout the emigration, within most of the available smolt habitat, and was also accomplished with minnow traps that would capture a wide range of smolt sizes encompassing the entire geographic range of smolt observed in the river. Because approximately equal effort occurred throughout the emigration, later running smolt may have had a higher probability of capture. Similarly, recovery effort was expended

Table 9.–Jolly Seber estimates of abundance (N), survival (φ), and recruitment (B) of adult coho salmon at Nakwasina River, 2002.

Period	Week(s)	Dates	$\hat{N}$	$SE(\hat{N})$	$\hat{\phi}$	$SE(\hat{\phi})$	$\hat{B}$	$SE(\hat{B})$
1	1	9/5-9//7	-	-	1.0*	0.0	320	293
2	2-4	9/8-9/28	320	284	0.52	0.19	1695	974
3	5-7	9/29-10/19	1400	1059	0.64	0.13	823	834
4	8	10/20-10/26	1549	189	1.0*	0.0	0*	670
5	9	10/27-11/2	1500	189	0.89	0.16	0*	343
6	10	11/3-11/9	1288	273	0.71	0.20	56	174
7	11	11/10-11/16	944	253	0.27	0.09	157	62
8	12	11/17-11/23	338	107	0.61	0.30	91	58
9	13	11/24-11/30	270	114	0.23	0.06	0*	-
10	14	12/1-12/3	60	13	-	-	-	-

Table 10.–Summary of goodness-of-fit tests for homogeneous capture/survival probabilities by tag group. Overall chi-squares are the sum of the individual test statistics.

Period	Component 1			Component 2		
	$\chi^2 \tau\alpha\tau\sigma$	df	P-value	$\chi^2 \tau\alpha\tau\sigma$	df	P-value
2	0.23-	1	0.63-	-	-	-
3	0.78	1	0.38	-	-	-
4	0.19	1	0.66	0.71	1	0.40
5	3.56	1	0.06	0.92	1	0.34
6	0.55	1	0.46	4.31	1	0.04
7	1.73	1	0.19	0.98	1	0.32
8	1.38	1	0.24	0.44	1	0.50
9	0.50	1	0.48	-	-	-
Overall	8.92	8	0.35	7.36	5	0.20

Table 11.–Results of χ^2 tests for differences in tagged rate between sections.

Location	Untagged	Tagged	Total	% of total captures by area
1	133	66	199	19%
2	421	82	503	48%
3	252	25	277	27%
Tide Water	63	0	63	6%
Total	869	173	1042	
Sections 1-3	χ^2	47.39	P <0.001	

Table 12.–Stream counts including number of coho counted, date, survey conditions, and percentage of total escapement estimate represented by daily count.

Date	Count	Conditions	% of total escapement	Comments
10/4/2002	226	Ideal-low- clear water	7.2%	Coho present in bay
10/24/2002	444	Low water- normal visibility-	14.1%	
11/5/2002	713	Ideal-low- clear water	22.7%	
11/20/2002	222	Low water- normal visibility-	7.1%	
12/3/2003	79	Low water- normal visibility-	2.5%	

throughout most of the run of returning adults, but not in exact proportion to fish abundance, and a small number of fish probably returned earlier or later than the tag recovery sampling.

Although the assumption about mixing cannot be tested, coho salmon most likely mixed within or across stocks during their extended time (14 months) at sea. This should provide adequate mixing of the population. In Nakwasina River catches, the fraction of adult coho salmon with marks (missing an adipose fin) did not vary significantly over time (Table 5). This indicates that at least one of the conditions in assumption 1 was satisfied.

Assumption 2 required that there was no recruitment to the population between years. Because almost all salmon return to their natal streams and sampling only occurred in the river, there was probably no appreciable recruitment to the stock between marking and recovery. We believe the presence of stray coho salmon reared at Medvejie hatchery is possible but unlikely given the geographical distance between the two sites.

Although we have no direct evidence, it is possible that the capture and tagging procedures caused fish to emigrate the system prematurely. This premature emigration would likely increase the mortality rate of tagged fish and subsequently bias the estimate of abundance high and the estimate of marine survival low. Based on the age composition observed for 2001 smolt, it is also possible that some fish tagged in 2001 remained in fresh water an additional year to smolt and emigrate in 2002. This would also bias the

abundance estimate high and the survival estimate low.

The smolt to adult survival rate of 9.4% is low, but comparable to other systems in the region. Average smolt to adult survival rates in other parts of the region range from 13.4% in Hugh Smith Lake (Shaul 1998) and 14% above Canyon Island in the Taku River to as high as 23% in Auke Lake (Yanuz et al. 1999). Because of the low average smolt to adult survival rate in the Nakwasina River in 1999-2001 (Average = 8.6%) extra care was taken in spring 2001 to insure smolt were given an adequate opportunity to recover and smolt naturally. Because survival remained relatively low in 2001-2002 (9.4%), we assume that the Nakwasina River coho have a naturally lower survival rate.

It is unlikely that smolt regenerated the clipped adipose fin that identified the fish as containing a tag. In conjunction with tag retention and overnight mortality tests, we examined adipose fin clips on smolt. All smolt examined appeared to have good fin clips. Also, all adult coho examined had well defined or a complete absence of an adipose fin.

ADULT ESCAPEMENT IN 2002

There were no indications to suggest problems with the abundance estimate; tag loss was low, sampling rates were high and assumptions of the JS experiment were met, and the JS model fit the data. Additionally, marking did not appear to affect the behavior or movement of fish, as marked fish were observed spawning with or near unmarked fish throughout the study.

A higher rate of recapture was observed for males than females during the adult escapement. This may have been due to error in determining the sex of fish early in the run. Because the secondary maturation characteristics had not fully developed earlier in the run, it is possible that some fish were misidentified as females. When recaptured, fish previously identified as females may have been identified as males. This would lead to an indication that a higher proportion of males were recaptured.

Some adult coho may not have had the same probability of capture as others because only river kilometers 3.4 to 7.75 were sampled. Differences were found in the fractions of fish carrying marks in upriver (33%%) and downriver (9%) locations. Because all areas were sampled approximately equally, fish may have had a greater chance of being sampled as it moved from downriver to upriver.

The fact that the JS estimations were constrained to yield admissible values suggests violation of assumptions of some kind were experienced in the experiment, although the escapement estimate is unlikely to be seriously effected by this problem (Schwarz et al. 1993). One explanation for the difficulty is temporary emigration and re-immigration of fish from the study area, perhaps due to stress associated with handling and tagging.

VISUAL COUNTS

The Nakwasina River is similar to other clearwater streams in the area, and the relationship between the peak observer count and the total escapement are typical for similar streams in Southeast Alaska (McPherson 1996; Jones and McPherson 1997). The ability to count spawning salmon depends on many factors, including the observer, weather, water clarity, canopy cover, pool-to-riffle ratio, the density of fish, the amount of undercut banks, and the ecology, behavior, size, and color of salmon (Jones 1995).

HARVEST SAMPLING

To assess the adequacy of sampling rates in the purse seine and gillnet fisheries, we examined troll harvests within Southeast Alaska where Nakwasina River coho salmon recovery occurred (Table 13). The overall sampling rate in the troll fishery in the Southwest Quadrant (Districts 104)

in period 4 was 51%. The troll fisheries in the Northwest Quadrant ranged from 27% (Districts 113) to 67% (District 189). Because not all fisheries were sampled, it is likely that Nakwasina River coho salmon harvest was underestimated in some fisheries.

The coho salmon harvest in the District 113 drift gillnet fishery was likely under reported and was not sampled. The only gillnet fishery within District 113 targets hatchery produced chum salmon in the Deep Inlet Terminal Harvest Area. This fishery was sampled for coho salmon CWT recovery September 21, 1999, when thirteen coho salmon were examined from only four vessels observed fishing. Fishers interviewed on each vessel reported similar or greater catches per boat-day during previous openings when fishing effort was higher. Fishers also reported that most coho were kept for home use and not recorded on fish tickets. For these reasons, the reported harvest of 509 coho salmon in 2002 probably represents only a fraction of the actual harvest, and the harvest of Nakwasina River coho salmon in this fishery was likely underestimated. In a similar study, Schmidt (1996) estimated that the Deep Inlet gillnet fishery harvested 7% of the total harvest of Salmon Lake coho (another Sitka Sound coho salmon stock) but considered that estimate biased low due to under reporting and sampling problems similar to those experienced during 1999 and 2002.

The smolt abundance estimate in 1999 (47,571) and 2000 (46,575) is similar to that in 2001 (43,630). In future tagging events, extra care should be taken to ensure that any potential effects of tagging are minimized. Recommendations for future tagging include:

1) releasing smolt in side tributaries with extensive available rearing habitat as opposed to mainstem areas with higher velocities;

2) minimizing transport distances by centralizing the tagging and holding site;

3) returning tagged smolt to locations near their capture site; and,

4) tagging and sampling all fish within 48 hours of capture to ensure fish are not held for periods greater than 72 hours, including overnight mortality testing.

Table 13.–Numbers of fish harvested and sampled for CWT recovery for districts in which Nakwasina River coho were recovered.

District	Gear Type	Fish Harvested	Fish Sampled	Proportion Sampled
104	Troll	76,533	39,106	0.51
109	Troll	177,547	59,617	0.34
113	Troll	494,296	132,405	0.27
154	Troll	26,276	9,011	0.34
189	Troll	20,387	13,561	0.67
		795,039	253,700	0.32

Future study designs should also address the problems encountered in sampling the 1999-2002 commercial purse seine and gillnet fisheries to ensure accurate harvest estimates and adequate CWT sampling rates, particularly for fisheries in District 113.

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APPENDIX A

Appendix A1.–Recoveries of coded wire tags originating from the Nakwasina River coho salmon during 2002.

Head	Tag Code	Gear Class	Recovery Date	Stat. Week	Quadrant	District	Sub-District	Length	Survey Site	Sample
					Random Recoveries					
228522	40466	SPORT	7/23/2002	30	NW	113	45	620	SITKA	2035400
228566	40367	SPORT	7/31/2002	31	NW	113	45	700	SITKA	2035468
228378	40466	SPORT	8/3/2002	31	NW	113	45	612	SITKA	2035442
233991	40466	SPORT	8/21/2002	34	NW	113	41	520	SITKA	2035638
233998	40368	SPORT	8/23/2002	34	NW	113	41	690	SITKA	2035645
229422	40367	SPORT	8/26/2002	35	NW	113	45	605	SITKA	2035692
228100	40466	SPORT	8/31/2002	35	NW	113	61	630	SITKA	2035690
229505	40367	SPORT	9/3/2002	36	NW	113	41	640	SITKA	2035701
31006	40466	TROLL	7/4/2002	27	NW			532	EXCURSION INLET	2100007
31097	40466	TROLL	7/10/2002	28	NW			616	EXCURSION INLET	2100027
207046	40367	TROLL	7/18/2002	29	NW	113	94	640	ELFIN COVE	2020039
169138	40466	TROLL	7/18/2002	29	NE	109	10	585	PORT ALEXANDER	2080023
213187	40466	TROLL	7/24/2002	30	NW	113	45	666	SITKA	2030917
213461	40466	TROLL	7/27/2002	30	NW	154		562	SITKA	2030944
213489	40367	TROLL	7/29/2002	31	NW	113	45	582	SITKA	2030948
212210	40466	TROLL	7/30/2002	31	NW	113	41	652	SITKA	2030953
78350	40367	TROLL	8/8/2002	32				594	KETCHIKAN	2060327
212741	40367	TROLL	8/16/2002	33	NW	113	31	637	SITKA	2031050
215011	40368	TROLL	8/19/2002	34	NW	113	31	574	SITKA	2031099
210245	40466	TROLL	8/20/2002	34	NW	113	91	655	PELICAN	2010264
215191	40367	TROLL	8/20/2002	34	NW	113	45	688	SITKA	2031111
215409	40368	TROLL	8/26/2002	35	NW	113	45	721	SITKA	2031153
214769	40367	TROLL	8/28/2002	35	NW	154		594	SITKA	2031173
68805	40466	TROLL	9/2/2002	36	SW	104	35	640	CRAIG	2070402
223002	40367	TROLL	9/3/2002	36	NW	189	30	673	YAKUTAT	2140069
210779	40367	TROLL	9/4/2002	36	NW	113		675	PELICAN	2010299
210800	40367	TROLL	9/6/2002	36	NW	113	91	625	PELICAN	2010304
216353	40367	TROLL	9/6/2002	36	NE	109	10	710	PORT ALEXANDER	2080151
216590	40367	TROLL	9/10/2002	37	NW	113	41	717	SITKA	2031250
236193	40466	TROLL	9/10/2002	37	NW	113	45	620	SITKA	2031253
236371	40367	TROLL	9/13/2002	37	NW	113	45	697	SITKA	2031258
236851	40466	TROLL	9/14/2002	37	NW	113	45	691	SITKA	2031262
210895	40466	TROLL	9/18/2002	38	NW			655	PELICAN	2010332
210944	40367	TROLL	9/20/2002	38	NW	113	91	638	PELICAN	2010342
237199	40466	TROLL	9/20/2002	38	NW	113	45	586	SITKA	2031277
237261	40466	TROLL	9/20/2002	38	NW	114	21	668	SITKA	2031279
210950	40466	TROLL	9/23/2002	39	NW	113	91	590	PELICAN	2010366
210949	40466	TROLL	9/23/2002	39	Quad	113	91	632	PELICAN	2010366
237285	40466	TROLL	9/23/2002	39	NW	113	45	716	SITKA	2031283
239011	40367	TROLL	9/25/2002	39	NW	113	91	650	PELICAN	2010356
237294	40367	TROLL	9/25/2002	39	NW	113	41	607	SITKA	2031289
239028	40466	TROLL	9/26/2002	39	NW	113	91	650	PELICAN	2010361
239019	40466	TROLL	9/26/2002	39	NW			833	PELICAN	2010360
237361	40368	TROLL	9/27/2002	39	NW			658	SITKA	2031300
236958	40466	TROLL	9/27/2002	39	NW	113	41	630	SITKA	2031297
236946	40466	TROLL	9/27/2002	39	NW	113	41	663	SITKA	2031297
223088	40367	TROLL	9/30/2002	40	NW	189	30	704	YAKUTAT	2140078
223083	40466	TROLL	9/30/2002	40	NW	189	30	686	YAKUTAT	2140078
236967	40367	TROLL	10/1/2002	40	NW	113		683	SITKA	2031309
					Select Recoveries					
228385	40367	SPORT	7/30/2002	31	NW	113	45		SITKA	2035444
236428	40466	TROLL	9/1/2002	36	NW	113	91		SITKA	2031237
236262	40367	TROLL	9/3/2002	36	NW	113	71		SITKA	2031234
236802	40466	TROLL	9/11/2002	37	NW	113			SITKA	2031254
216735	40368	SPORT	10/2/2002	40	NW	113	43	695	SITKA	2035728

Appendix A2.–Detection of size-selectivity in sampling and its effects on estimation of abundance and age and size composition.

Week#	Location	Original Captures	Recaptures	Total Captures	Proportion Tagged
1	2	6		6	0.00
2	2	8	1	9	0.11
3	2	3		3	0.00
	Tide Water	14		14	0.00
4	2	34		34	0.00
	3	3		3	0.00
	Tide Water	1		1	0.00
5	2	23	2	25	0.08
	Tide Water	1		1	0.00
6	2	10		10	0.00
	Tide Water	2		2	0.00
7	2	63	1	64	0.02
	Tide Water	1		1	0.00
8	1	2		2	0.00
	2	29	1	30	0.03
	3	105	3	108	0.03
9	1	37	5	42	0.12
	2	44	6	50	0.12
	3	39	4	43	0.09
	Tide Water	44		44	0.00
10	1	23	12	35	0.34
	2	77	20	97	0.21
	3	52	10	62	0.16
11	1	53	29	82	0.35
	2	52	20	72	0.28
	3	35	4	39	0.10
12	1	10	10	20	0.50
	2	36	13	49	0.27
	3	12	2	14	0.14
13	2	36	18	54	0.33
	3	5		5	0.00
14	1	8	10	18	0.56
	3	1	2	3	0.67
Grand Total		**869**	**173**	**1,042**	**0.17**

Appendix A3.– Estimation of the Ratio of Catchabilities.

The fraction p of adults with 1-freshwater age can be expressed as:

$$p = \frac{N_1\phi_1 S_1 + N_2\phi_2 S_2}{N_1 S_1 + N_2 S_2} = \frac{N_1\phi_1 S_1 + N_2\phi_2 B S_1}{N_1 S_1 + N_2 B S_1} = \frac{N_1\phi_1 + N_2\phi_2 B}{N_1 + N_2 B}$$

where N is smolt number by smolt size group, S their survival rate, ϕ the fraction of the smolt group comprised of smolt age 1-freshwater, and B is the ratio of survival rates S_2/S_1. This relationship simplifies to:

$$\frac{N_1}{N_2} = \frac{B(\phi_2 - p)}{(p - \phi_1)}$$

If α is the capture rate of smolts, then $M_1 = \alpha_1 N_1$ and $M_2 = \alpha_2 N_2$, and:

$$\frac{N_1}{N_2} = \frac{M_1}{M_2}\frac{\alpha_2}{\alpha_1} = \frac{B(\phi_2 - p)}{(p - \phi_1)}$$

If A is the ratio of catchability for the two groups of smolts, then $A = \alpha_2/\alpha_1$ since fishing effort by definition is equal for both groups. Substitution creates:

$$A = \frac{M_2 B(\phi_2 - p)}{M_1(p - \phi_1)}$$

A naïve estimate of A is therefore:

$$\hat{A} = \frac{M_2 \hat{B}(\hat{\phi}_2 - \hat{p})}{M_1(\hat{p} - \hat{\phi}_1)}$$

Noting that the estimate for the ratio of survival rates is:

$$\hat{B} = \frac{T_2}{M_2}\frac{M_1}{T_1}$$

A simpler estimate for A is:

$$\hat{A} = \frac{T_2(\hat{\phi}_2 - \hat{p})}{T_1(\hat{p} - \hat{\phi}_1)}$$

Appendix A4.–Detection of size-selectivity in sampling and its effects on estimation of abundance and age and size composition.

RESULTS OF HYPOTHESIS TESTS, *K-S* ON LENGTHS OF FISH

Marked VS Recaptures   Marks VS Captures

Case I:

   Accept H_O Accept H_O

There is no size-selectivity during marking or recapture, gear types, or locations.

Case II:

   Accept H_O Reject H_O

There is no size-selectivity during recapture but there is during marking.

Case III:

   Reject H_O Accept H_O

There is size-selectivity during both marking and recapture, between all gear types, or all locations.

Case IV:

   Reject H_O Reject H_O

There is size-selectivity during recapture; the status of size-selectivity during marking is unknown.

Case I: Calculate one unstratified abundance estimate, and pool lengths, sexes, and ages from both marking and recapture events to improve precision of proportions in estimates of composition.

Case II: Calculate one unstratified abundance estimate, and only use lengths, sexes, and ages from recapture to estimate proportions in compositions.

Case III: Completely stratify both sampling events, and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Pool lengths, ages, and sexes from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for size bias to the pooled data (p. 17).

Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Use lengths, ages, and sexes from only recapture to estimate proportions in compositions, and apply formulae to correct for size bias to the data from recapture.

Whenever the results of the hypothesis tests indicate that there has been size-selective sampling (Case III or IV), there is still a chance that the bias in estimates of abundance from this phenomenon is negligible. Produce a second estimate of abundance by not stratifying the data as recommended above. If the two estimates (stratified and unbiased vs. biased and unstratified) are dissimilar, the bias is meaningful, the stratified estimate should be used, and data on compositions should be analyzed as described above for Cases III or IV. However, if the two estimates of abundance are similar, the bias is negligible in the UNSTRATIFIED estimate, and analysis can proceed as if there were no size-selective sampling during Event 2 (Cases I or II).

Data File[a]	Description
2002_Adult_CWT_Recoveries.xls	Recovery information from 2002 Coded Wire Tag recoveries in Southeast Alaska.
Nakwasina_River_2002_M-R_and_CWT.xls	Mark, recapture, and coded wire tag recovery information from fish captured in the Nakwasina River in 2002.
2002AdultAWL.xls	Age and length Information including summary statistics of adult coho captured in the Nakwasina River in 2002.
2001_smolt_AWL_data.xls	2001 smolt raw data including summaries of analyzed data.

[a] Data files were archived at and are available from the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1599.